Storm Water "Green Infrastructure" and its Potential Impacts on Groundwater

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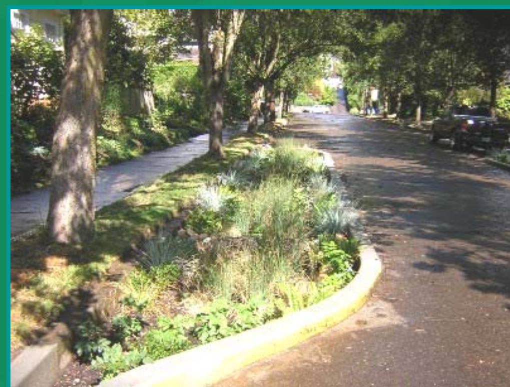


The Center for Neighborhood Technology

- 30 year old Chicago-based non-profit that develops and promotes…
- Sustainable urban development strategies through:
  - Research
  - Education
  - Advocacy
  - Demonstration projects
  - Scaling up, replication
- Green Infrastructure agenda
  - Planning/Analysis Toolbox
  - Policy
  - Education
  - Practice

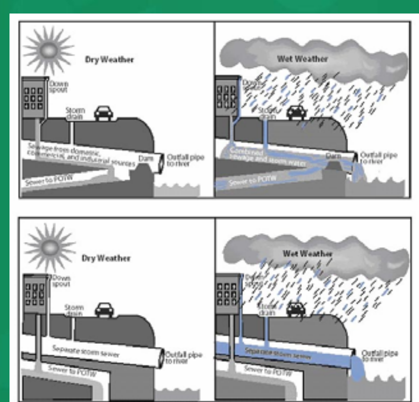
Traditional Approach to Urban Storm Water Management: Collect it All, Treat Some (maybe)…

- Older urban systems combine storm water with domestic sewage, treat the first partial inch of rainfall along with domestic sewage
- This uses large amounts of energy:
  - Pumping
  - Treating
- Uses large quantities of treatment chemicals
- Or: separated sewer system

The Traditional Approach to Urban Storm Water Management – only works sometimes:

…***combined sewers*** overflow to surface waters; or

…***separated sewers*** discharge all their water to surface waters – <u>untreated</u>.



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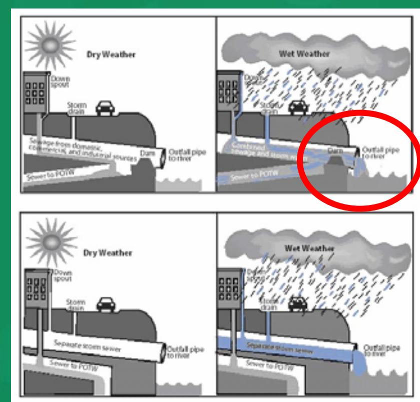


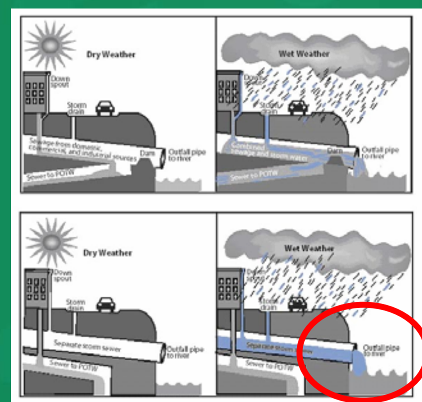
The Traditional Approach to Urban Storm Water Management – we get what we pay for:

With a Combined Sewer Overflow, you get it all!

The Traditional Approach to Urban Storm Water Management – only works sometimes:

…***combined sewers*** overflow to surface waters; or

…***separated sewers*** discharge all their water to surface waters – <u>untreated</u>.



What About Uncombined Storm Water?

Uncombined storm water is not inherently clean either…

You Might be Surprised What You Find in Storm Water if You Look!

What is Green Infrastructure?

Green Infrastructure means –

Wet weather management approaches and technologies that utilize, enhance or mimic the natural hydrologic cycle processes of infiltration, evapotranspiration and reuse.

More Than Just Rain Gardens and Rain Barrels

Typical Green Infrastructure best management practice (BMP) hierarchy for development – found in some ordinances – includes the following:

1. Preservation of the natural features of development sites, including natural storage and infiltration characteristics;
2. Preservation of existing natural streams, channels, and drainage ways;
3. Minimization of new impervious surfaces;
4. Conveyance of storm water in open vegetated channels;
5. Construction of structures that provide both quantity and quality control, with structures serving multiple sites being preferable to those serving individual sites; and
6. Construction of structures that provide only quantity control, with structures serving multiple sites being preferable to those serving individual sites.

Neo-Traditional Storm Water Management Techniques

Somewhat Newer Approaches to Water Quality and Water Quantity Problems:

- **“Detention” – wet and dry basins**
- **“Release Rates” – restrictions prevent flooding and overflows and allow for increased treatment**
- **“Retention” (aka “volume control”) – keeps storm water on site permanently**

Volume Control Requirements Can Encourage the Use of Green Infrastructure

Example: Post−construction performance standard for new development and redevelopment:

Infiltration. BMPs shall be designed, installed and maintained to infiltrate runoff…so that the post−development infiltration volume shall be at least 90% of the pre−development infiltration volume, based on an average annual rainfall.

Wisconsin Code Section NR 151.12(5)(c)(1)(a).

Portland, Oregon "Green Streets" Program

This Hierarchy Favors the Use of Green Infrastructure

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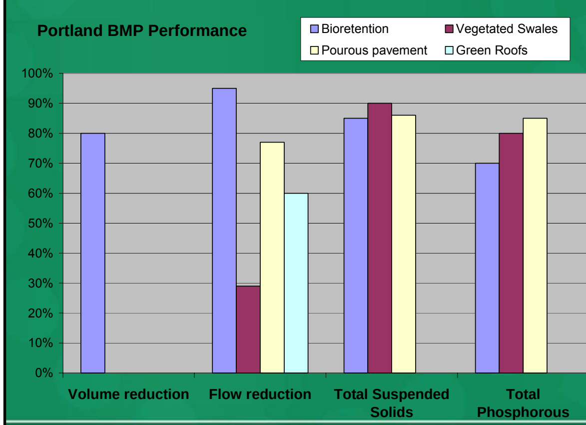
6. Construction of structures that provide only quantity control, with structures serving multiple sites being preferable to those serving individual sites.

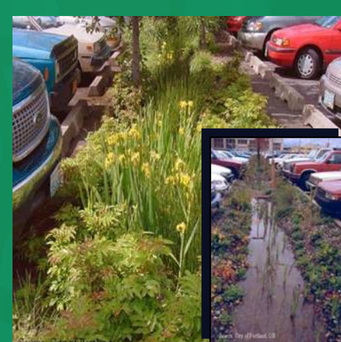
How to Meet Infiltration Standards?

Other possible green infrastructure techniques to meet the standard include:

- Green roofs
- Trees and tree boxes
- Rain gardens
- Vegetated swales, pocket wetlands
- Infiltration planters
- Porous and permeable pavements
- Dry wells and porous piping systems
- Reforestation/revegetation
- Rain barrels and cisterns
- Protection and enhancement of riparian buffers and floodplains.

Green Infrastructure is a well documented alternative to traditional stormwater management techniques

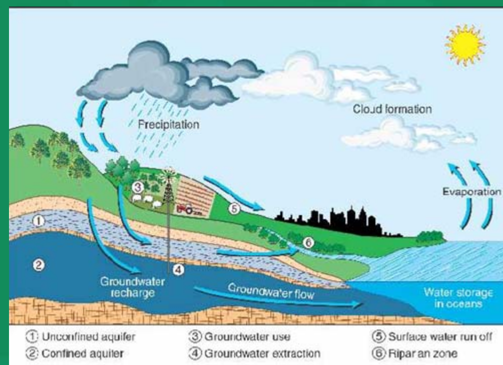




Potential Groundwater Impacts from Infiltration

Pollutants studied:

- Nutrients
- Heavy metals
- Organics
- Pathogens
- Suspended solids
- Salts



Groundwater Impacts from Infiltration

<u>Phosphorous and Nitrogen</u>

- Environmental impacts: algal blooms, eutrophication, adverse health impacts
- Storm water sources: motor oil, animal waste, plant material, fertilizers, air pollutant deposition
- Loading correlates well with intensity of land use; e.g., loading increases logarithmically with impervious surface where curbs and gutters are used.

Groundwater Impacts from Infiltration

Phosphorous and Nitrogen

Pollutant retention by infiltration systems:

- Mixed results: for Phosphorous, -55% to 100% removal by urban wet detention ponds; rain garden study showed phosphorous tended to leach out rather than being retained; for Nitrogen, <50%, with higher organic content of the medium correlated with higher retention rates

- Factors affecting retention: pH, organic component of soil media, presence of living matter

Groundwater Impacts from Infiltration

Heavy metals **(lead, copper, zinc, cadmium)**

- Storm water sources: streets, parking areas, buildings

- Loading: increases with increased impervious surface and traffic intensity (except, possibly, for cadmium)

Pollutant retention by infiltration systems:

- Rates generally 50% to 99%, with the higher rates being found in the laboratory studies; also higher sand content in the medium correlated with higher retention rates

Groundwater Impacts from Infiltration

Suspended solids

- Found in virtually all storm water; construction and other land disturbing activities leading contributors
- Important because other pollutants adhere to them; reduce sunlight in surface waters
- Retention rates from infiltration vary widely, 29% to 99%, probably due to site conditions

Groundwater Impacts from Infiltration

Organic Compounds

- Environmental impacts: can be acutely toxic to humans and wildlife; very low surface and drinking water standards
- Storm water sources: streets, parking areas, spills, leaks, USTs, ASTs
- Loading: increases with increased impervious surface, traffic intensity and commercial and industrial activities

Groundwater Impacts from Infiltration

Organic Compounds

Pollutant retention by infiltration systems:

- For certain heavy organics, such as motor oil, rates in laboratory simulations show >95% retention; however, volatility, mobility and degradation issues, as well as soil medium variations from place to place significantly complicate the potential fate of organics in soil and groundwater (think: brownfields; Superfund)

Groundwater Impacts from Infiltration

Pathogens

- Bacteria and viruses are prevalent in urban runoff, and may exceed federal water quality criteria during and after storm events
- Concentrations not based on land use, but strongly affected by temperature; survival rate depends on conditions (pH, temperature, presence of metals and organic matter)
- Retention in infiltration systems highly variable

Groundwater Impacts from Infiltration

Salts – sodium, potassium, magnesium and calcium chloride

- Exposure to NaCl inhibits some soil bacteria at low levels, which compromises soil structure and increases erosion.
- Elevated sodium and chloride in soils inhibit water absorption by plants and reduce root growth. Salts also disrupt nutrient uptake and inhibit long-term plant growth.
- Chlorides (60% of deicing salts) are soluble ions, do not readily adhere to soil particles; and thus readily reach groundwater. Positive ions are also soluble, but (with the exception of Na) tend to combine with negatively charged soil particles, potentially releasing heavy metals.
- Chloride concentrations have been increasing in streams in certain parts of the country and may eventually threaten wildlife.
- One study showed that about 55% of road salt chlorides are transported in surface runoff, with the remaining 45% infiltrating into aquifers.

Conclusions:

1. Studies of storm water infiltration and contaminant impacts on groundwater tend to be short-term, do not cover many rain events, frequently are only laboratory simulations, and in the field focus on a narrow set of geologic conditions.

2. With the exception of road salt, we cannot generalize about how storm water contaminants might impact local groundwater through the use of infiltration practices.

3. Because of the variability in contaminant retention rates, we should be careful about using soils and aquifers as storm water management systems.

Conclusions:

4. Non-infiltration green infrastructure practices are the most cost effective and safest approach to storm water management in most situations. Modified infiltration is also viable.

5. A number of green infrastructure strategies incorporate aquifer protection techniques:

   a. Preservation of open space, trees and other vegetation
   b. Minimization of impervious surfaces
   c. Green roofs
   d. Lined bioswales with underdrains leading to treatment
   e. Storm water capture and reuse systems

6. In some cases, infiltration may be appropriate, e.g., where storm water contamination is minimal and geology is compatible, such as residential areas.

How Do We Protect Groundwater Quality?

1. Minimize contamination by regulating sources of pollutants (using green infrastructure minimizes the generation of pollutants).

2. Minimize contamination by regulating the methods by which storm water is contaminated (using green infrastructure minimizes the methods of storm water contamination).

3. Identify and map all groundwater recharge and other sensitive areas. Ensure this information is widely available.

Center for Neighborhood Technology

How Do We Protect Groundwater Quality?

4. Prohibit infiltration in all sensitive areas unless pretreatment is provided.

5. Require the use of green infrastructure hierarchy and best management practices that do not involve infiltration of excess storm water.

6. Establish pretreatment requirements for storm water entering infiltration systems, depending on land use. (See example)

Example State Regulation

4. Before infiltrating runoff, ***pretreatment*** shall be required for parking lot runoff and for runoff from new road construction in commercial, industrial and institutional areas that will enter an infiltration system. The pretreatment shall be designed to protect the infiltration system from clogging prior to scheduled maintenance ***and to protect groundwater quality***….Pretreatment options may include, but are not limited to, oil/grease separation, sedimentation, biofiltration, filtration, swales or filter strips. (Emphasis added)

Wisconsin Code Section NR 151.12(5)(c)(4)

Lined Infiltration =
filtration + detention

How Do We Protect Groundwater Quality?

7. Require long-term testing and monitoring of all urban storm water, particularly where it enters green infrastructure systems, such as an infiltration, reuse or evapotranspiration system.

8. Further develop BMPs by performing studies on fate and transport of pollutants under different geological conditions over several years to monitor accumulation in infiltration systems and changes in soil and water chemistry, identify breakthrough times and establish protocols for media replacement, if necessary.

Education and Outreach

We need to work together to protect water quality.

What Works, and What Does Not

Band Aid Approach?

Sustainable Strategies

- No drains
- No curbs
- Narrow streets
- Permeable sidewalks
- Rain gardens
- Trees

Thank You

www.cnt.org/natural-resources

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